

A preliminary investigation of the distribution of koalas and their potential habitat in the Tweed Shire, and implications for management

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ABSTRACT

The conservation of koala habitat was identified by Tweed Shire Council in 1989 as a priority for investigation to aid planning and decision making. The aim of this study was to determine the distribution of koalas in the shire and to identify potential koala habitat. This was achieved by personal interviews, invitations to the community to report local koala sightings and a literature search. This paper also identifies those planning considerations and constraints that exist within the shire which are relevant to koala preservation. Examples of planning instruments that can affect koala security (e.g., local environmental plan zonings) are also examined. Other issues highlighted include the potential impact of expanding development within the shire and the need for community awareness of the principles underlying koala preservation. The major finding of the study was that the Round Mountain-Cudgen Lake environs hold special importance for koala conservation. Co-operation of the community, rural landholders, Tweed Shire Council, relevant State Government departments (e.g., Department of Planning, National Parks and Wildlife Service) will be required before a management plan can be expected to succeed.

INTRODUCTION

On July 5, 1989, Tweed Shire Council resolved to pursue studies with National Parks and Wildlife Service (Lismore District) on the koala *Phascolarctos cinereus* to ensure that koala habitat in the shire are identified and preserved for the future. Upon recommendation from the National Parks and Wildlife Service, the School of Resource Science and Management at the University of New England, Northern Rivers, was approached in 1989 for completion of a Koala Management Plan. The results were submitted to Tweed Shire Council to assist future planning and decision making. The study aimed to identify the present distribution of the koala and its likely habitat within the shire to help ensure its protection. The desirability for a management plan arises from the perception that increasing agricultural, tourist and urban development may have on the koala and its habitat.

STUDY AREA

Tweed Shire, in the north-east corner of New South Wales between the Great Dividing Range and the ocean, covers 130 277 hectares. It is dominated by ridges and valleys around the Tweed, Rous and Oxley Rivers. The narrow coastal plain rises up to a small plateau associated with the Condong and Burringbar Ranges. The coastal catchment comprises several eastward-draining creeks: Mooball, Cudgen and Cudgera. North, west and south of the Tweed River are the rugged foothills of the McPherson, Tweed and Nightcap Ranges; the remnant caldera rim of the Mount Warning Shield Volcano.

Mount Warning (1 157 m) is the major feature of the 2 210 ha New South Wales World Heritage Rainforest Park. Much of the rugged mountainous ranges of the caldera rim which have remained essentially undisturbed from clearing of the surrounding country, now lie within Lamington, Border Ranges and Nightcap National Parks and Limpinwood (2 443 ha) and Numinbah (800 ha) Nature Reserves (NSW NPWS 1987). The State Forests include Mebbin (4 001 ha), Wollumbin (2 489 ha), Nullum (part of 4 930 ha), Mooball (1 173 ha) and Burringbar (70 ha) (Forestry Commission of NSW 1984). They are managed for timber.

Cultivation of sugar cane is the predominant land use in the Tweed Valley floodplain, and almost all the floodplain downstream from Murwillumbah is devoted to sugar cane (Soros-Longworth *et al.* 1980). Bananas are grown on the steeper slopes. Grazing of cattle occurs on the river flats upstream from Murwillumbah, along the small creeks draining to the Cobaki and Terranora Broadwaters and in some areas of the coastal floodplain. Some flood-free areas are used for cropping. Small-scale commercial forestry has also been introduced to the coastal floodplain (Soros-Longworth *et al.* 1980). About 14% of the shire area is prime agricultural land (TSC 1983).

The major commercial and administrative centres are Tweed Heads and Murwillumbah. The North Coast Regional Environmental Plan (DEP 1988) nominates Kingscliff, a long established resort town adjacent to Cudgen Lake, as one of six prime tourist development areas. Tweed Heads is another.

The shire has one of the fastest growing populations in New South Wales with estimates of a future population of 82 581 by the year 2001 (TSC and DEP 1987). As a result, much pressure is being placed on natural areas from development, pollution, exotic weeds and feral animals; also for conversion of prime agricultural land to urban or semi-rural land uses. The Residential Development Strategy (TSC and DEP 1987) forms the basis on which local environmental plans (LEPs) will be used to rezone land for urban purposes and on which the Council will draw up development control plans for the new urban areas.

The North Coast Regional Environmental Plan (DEP 1988) requires environmental or scenically significant areas to be zoned "environmental protection"; and urban development strategies prepared by the local council should identify land suitable for urban expansion which avoids environmentally sensitive areas. The Tweed LEP (DEP 1987) currently makes provisions for environmental protection of areas or features identified as being of particular habitat significance for flora and fauna, including wildlife corridors, under 7(l) — Environment Protection (Habitat). Other "Environmental Protection" zones may function as *de facto* habitat protection, i.e.

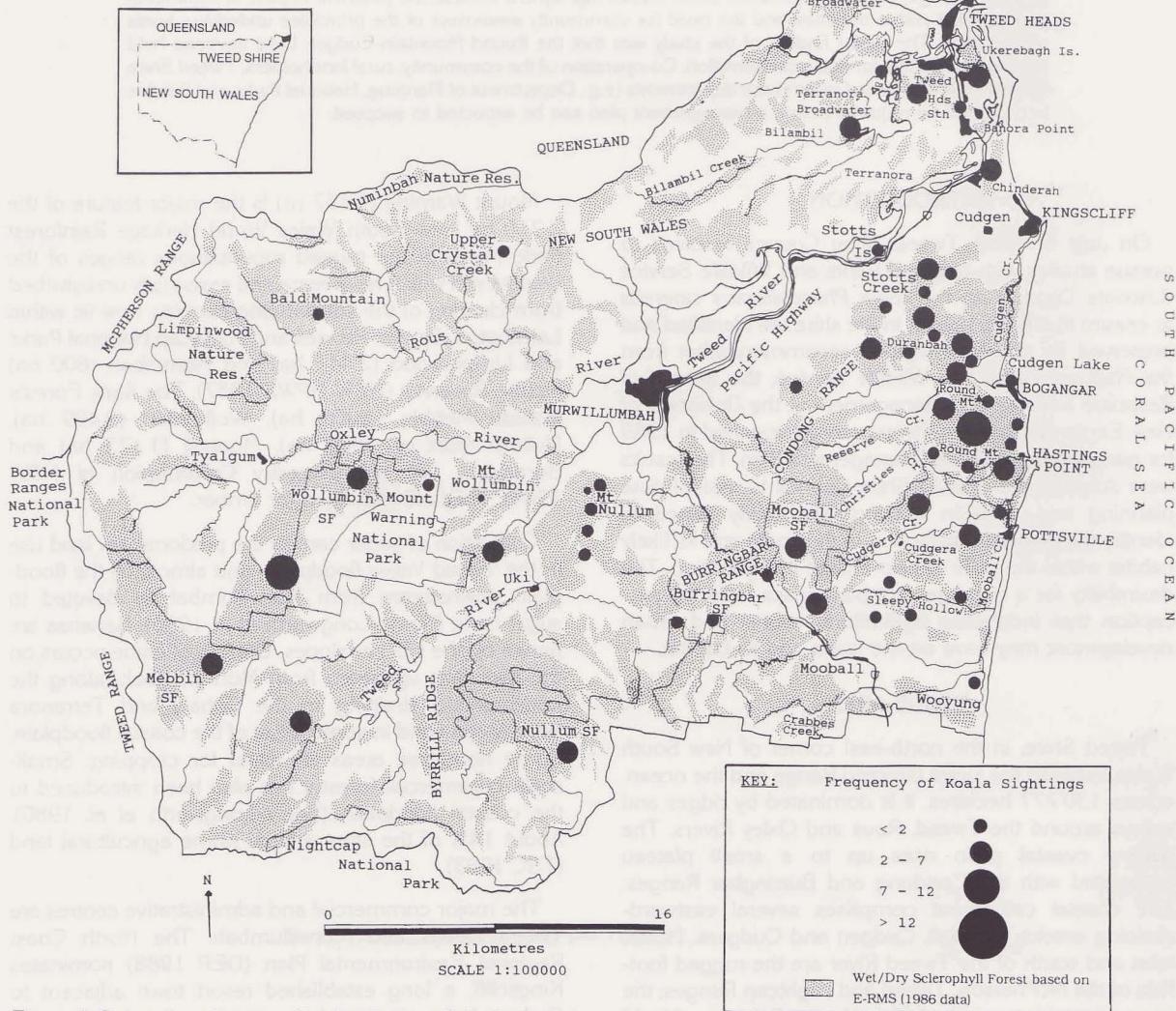


Figure 1. Comparison between the distribution of the koala in the Tweed Shire and potential koala habitat.

7(d) — Environmental Protection (Scenic/Escarpment), 7(a) — Environmental Protection (Wetlands) and 7(f) — Environmental Protection (Coastal Lands).

"Environmental Protection" zones do not make areas secure for wildlife habitat unless adequately enforced. In general, development within "Environmental Protection" zones is restricted and requires consent from Tweed Shire Council. Removal of vegetation is prohibited, except with the consent of the Council. Secure wildlife habitat areas lie within national parks and nature reserves (Zone 8(a)) and, to a lesser extent, in state forests (Zone 1(f)). The "Environmental Protection" zones within the shire, in their present form, attempt to link inland state forests, national parks and nature reserves to coastal areas through rural lands which increases their value as wildlife corridors.

Although no specific provisions are made under the LEP for koalas, the "Environmental Protection" zones, particularly zone 7(l), do consider important wildlife communities. Koalas on private and leasehold lands should be able to be conserved by controls that restrict clearing of timber. Local government has a great deal of influence over landuse at this level. There are Tree Preservation Orders in place within the shire where it is an offence to lop or fell designated trees in areas of environmental significance (nominated by the Council). These largely coincide with current "Environmental Protection" zones.

DISTRIBUTION OF KOALAS

Historical Information and Past Surveys

Historical records of the distribution and abundance are limited. In 1949, a New South Wales Koala Survey, carried out by the Fauna Protection Panel, revealed that the greatest number of koala sightings were on the far north coast, including Tweed Shire (in Reed *et al.* 1990).

A more comprehensive survey of koalas in New South Wales in 1986–87 also found that concentrations of sightings occurred on the north coast, including Lismore through to Tweed Heads (Reed *et al.* 1990). Mooball, Nullum, Wollumbin and Mebbin State Forests were reported to contain koalas, as were Stotts Island Nature Reserve, Border Ranges National Park, and Mount Warning National Park.

In the Tweed Shire, Wells *et al.* (1984) estimated that since European discovery 80% of forest and woodland, much of which would have been suitable koala habitat, has been severely modified by either clearing of the upper stratum and widespread modification of the lower stratum with introduced species (including Camphor laurel *Cinnamomum camphora*), or no continuous vegetation at all. The areas left uncleared were those unsuitable for agriculture (Reed *et al.* 1990). Present

state forests and national parks are largely drawn from these areas. Forests were retained along the length of water courses and as scattered shade trees in paddocks.

The extensive modification of the forest and woodlands within the shire suggests a decline in range and population of the koala since its distribution is controlled by the presence of preferred food tree species (Reed *et al.* 1990). The nutrient-rich forested valley country, which became the cleared rural lands, would have contained the prime koala habitat since the koala primarily lives in trees of nutrient rich soils (Reed *et al.* 1990). The continued presence of koalas in rural areas with high levels of stock grazing supports this view.

Present Survey

The short time available for the study (August to November 1989) precluded a field census of koalas. The procedure for this study was to search relevant documents and files, and to conduct interviews with likely sources for information on the presence or absence of koalas. Reviews of records and personal communications with state government departments (e.g., National Parks and Wildlife Service, Forestry Commission of NSW), special interest groups/individuals (who kept files on koala sightings) and several landowners were made regarding the distribution of the koala in the shire. A literature review of seven wildlife surveys, environmental studies and Environmental Impact Statements (EISs) were checked for references to koalas. It was not the intention of this survey to determine koala abundance, therefore, the sighting information is presented as "Frequency of Sightings". All records from 1985 to 1989 were used and 120 koala sightings were obtained. Figure 1 shows the distribution of koalas. Less than two sighting records refers to either individual or infrequent sightings in an area. In a few instances, koalas were known to occupy an area, although their exact location could not be supplied. This was the case for Mount Warning National Park, Bald Mountain, Upper Crystal Creek, Mt Nullum, Stotts Island Nature Reserve and Terranora Heights. Other sighting information may contain overlapping records on koalas as different sources provided details. No records of greater than 12 sightings for an area were recorded.

The results from each group were:

1. *National Parks and Wildlife Service.* Twelve individual sightings were in the files of the Lismore District Office received from landowners near Hastings Point, the northern section of Condong Range and Burringbar (including Burringbar and Nullum State Forests). The 1986–87 state-wide survey by Reed *et al.* (1990) provided information on individual/intermittent sightings from Stotts Island Nature Reserve.

2. Forestry Commission (*Murwillumbah District*).

Commission records reported up to three to four sightings per year in each of the five state forests. [The shaded closed circles (Fig. 1) do not represent the exact location of the sightings, except for north Nullum and Burringbar State Forests.] Outside the state forests, Bald Mountain and Upper Crystal Creek were identified as containing koalas. Crabbes Creek, Burringbar Range and ridges of hardwood radiating out of Nullum State Forest are believed by Commission staff to be occupied by koalas.

3. Special Interest Groups/Individuals and Landowners.

Sixty-seven koala sightings were obtained and from personal communication with four landowners, five additional areas were identified as containing koalas. This included freehold land near Sleepy Hollow and land adjoining Cudgen Lake. Koalas were reported at Mt Nullum (to the immediate north and to the south) although their frequency and exact locations were not known. The sightings in the Mount Warning region were from freehold land, i.e., Portion 66 (Wollumbin Parish) which adjoins a Wildlife Sanctuary and Portion 46 (Burrell Parish) which adjoins Wollumbin State Forest. Frequent sightings of koalas along Cudgera Road (between the Cudgera Creek and Round Mountain Villages), Round Mountain Road and the area north of Duranbah to Stotts Creek were reported. Seven koalas (five adults and two cubs) were reported to be in the reserve adjacent to the Broadwater Esplanade, Bilambil Heights. Another five to six koalas were reported in Tweed Heads South near Dry Dock Road and the crematorium. Sextons Hill was believed to support four koalas. Further development and clearing of habitat of this area has occurred over the last year, and three koala deaths on the Pacific Highway were reported during 1989, which may be attributable to the loss of vegetation in this area. Koalas were recorded as being regularly seen on the grounds of the Tweed Heads-Coolangatta Golf Club. Staff at Minjungbal Resource Museum and Study Centre, north of the golf club, reported four to five koalas during 1989 in Ulkerebagh Nature Reserve. Wooyung Caravan Park reported seeing koalas intermittently.

4. Literature Review. "The Tweed Coast Plan — Biophysical Study" (NSW Plan. and Environ. Comm. 1979b) and the "Tweed Shire Coastal Planning Study — Wildlife" (NSW Plan. and Environ. Comm. 1979a) identified Ulkerebagh Island and the lowlands between Tweed Heads South and Banora Point as supporting koalas. The "Wildlife Survey of Mebbin Springs" by Gilmore and Milledge (1984) recorded three koalas. The "Mt Nullum Supplementary Environmental Study" (McCotter *et al.* 1988) described koalas as "highly mobile" and "predicted" that they were not present in the proposed development site (to the immediate south of Mt Nullum),

although they were reported to be in this area by other sources. Koalas were thought to be located in Mount Warning National Park, Wollumbin State Forest and adjacent freehold, and Burringbar Range (north Nullum State Forest to Mooball State Forest). In "A Survey of the Vertebrate Fauna of the Round Mountain-Cudgen Lake Area", Milledge (1988) recorded nine koalas during survey work for the proposed Cudgen Nature Reserve and estimated koala density at 1 per hectare. "Bilambil Heights Project, Local Environment Study" (TSC 1989) makes reference to the possibility of koalas within this area, and the "Pottsville Bicentennial Leisure Gardens Environmental Impact Statement" (TSC 1987a) records the presence of koalas on Crown land north of Pottsville and west to Cudgera Creek.

The studies examined, with the exception of that by Milledge (1988), were very limited in their coverage of koalas, i.e., they either "note" or "predict" their presence but do not attempt to interpret this fact. To overcome this problem, fauna reviews for planning studies should be required to focus in more detail on animals of special interest, or further studies should be recommended prior to planning decisions being made.

Interpretation of Koala Distribution

Koalas were found on the coastal plain and ranges from Ulkerebagh Nature Reserve in the north, to Wooyung in the south. Sightings were concentrated in the Round Mountain-Cudgen Lake area and along the ridges associated with the Condong Range (north of Duranbah to Stotts Creek). Most sightings were from steeper terrain, although areas of coastal lowlands surrounding Pottsville support koalas. Sightings in Bogangar Village possibly represent wandering animals from the Round Mountain environs.

Koalas were reported at low densities in state forests of the Tweed Shire and this is reflected in the number of sightings obtained for these areas. The north of Nullum and Burringbar State Forests are joined to Mooball State Forest by Burringbar Range, and this possibly acts as a corridor for the movement of koalas. The Forestry Commission considers that the hazard reduction fire regimes in state forests have little effect on koalas (Kooyman, pers. comm., 1989). Burning is carried out during the cooler months when low intensity heat is produced, and crown fire is minimal. Road edges and freehold land boundaries are burnt. Firing is also used to secure younger stands of regrowth.

Inland of the coastal strip, other significant areas for koalas were near Mount Warning. Freehold land adjacent to Wollumbin State Forest and Mount Warning National Park recorded common sightings. The presence of koalas in the surrounds of Mt Nullum require further

clarification because of conflicting reports. To the north of Mount Warning, koalas were recorded at Bald Mountain and Upper Crystal Creek, although exact locations were not known, and to the south at Mebbin Springs. The remaining freehold land in the western section of the Shire may contain koalas but no land-owners were contacted during the study.

Koalas at Bilambil Heights occupy the reserve adjoining the Terranora Broadwater. The development of Tweed Heads South and associated land clearing isolated koalas into pockets of vegetation at the crematorium and along Dry Dock Road. Some five to six koalas remained in the area until their relocation to Round Mountain was undertaken in 1990 by National Parks and Wildlife Service as freeway construction by the Road and Transport Authority removed the remaining habitat (Phillips, pers. comm., 1991). National Parks and Wildlife Service utilized radiotelemetry equipment to monitor the movements of the translocated koalas following their release.

POTENTIAL KOALA HABITAT IN TWEED SHIRE

Preferred tree species, soil type, vegetation structure (open woodland formation or denser) and suitable climate for tree growth and production of good quality food are possibly all important interrelating factors that make some areas suitable and others unsuitable for koalas. If koalas are present in large numbers and are there permanently, it may be assumed that the site has suitable habitat (Gordon 1988). A description of prime koala habitat in terms of individual preferred tree species is proposed by Cork *et al.* (1988) as inadequate because of the influence of soil fertility and other environmental factors on the quality of food for koalas. Gordon (1988) suggests that koalas concentrate in patches of suitable habitat with the better quality food supply. Cork *et al.* (1988) consider that the most reliable way to assess the extent and distribution of habitat for koalas is through relating direct observations of koalas to tree communities, then mapping the distribution of preferred tree communities. Identification of potential koala habitat in the Tweed Shire has been made using this approach and reflects the presence of preferred food trees. Also comparison of the distribution of koalas in the shire was made with the remaining wet and dry sclerophyll forest. Finally, areas of particular value to koalas were identified as were key sites for conservation, including corridors.

Distribution of Potential Koala Habitat

A vegetation map of wet and dry sclerophyll forest in the Tweed Shire was generated from Landsat data for 1986 using the National Parks and Wildlife Service's

"Environmental Resource Mapping System" (E-RMS) (Fig. 1). Some clearing of potential koala habitat may have taken place since 1986. Camphor laurel trees have been misinterpreted for wet and dry sclerophyll forest in some instances and further ground truthing of this type of vegetation in areas used by koalas is needed.

Potential koala habitat is extensive throughout the shire since open forests represent the majority of the vegetation (NSW Plan. and Environ. Comm. 1979b). The historical land clearing or partial clearing (especially of the fertile areas) has meant that much of the vegetation has been disturbed and, in many cases, is regenerating. State forests, which are primarily managed for their timber resources and therefore altered to suit commercial requirements, particularly exhibit this feature. Areas of Flooded Gum *Eucalyptus grandis* and Blackbutt *E. pilularis* have been planted in Mebbin and Mooball State Forests. Other areas have been disturbed by agriculture, urbanization, fire, sand mining and invasion by exotic weeds and pests.

A continuous coverage of koala habitat occurs in the Cudgen Lake, Round Mountain and Hastings Point areas, and to the north along the ridges to Stotts Creek. The larger open forests of the Condong Range act as a link to Mooball State Forest immediately to the south. Other areas, particularly along the floodplain to the north of Murwillumbah and the coastal areas to the south of Hastings Point, have little koala habitat because of the extensive growing of sugar cane. However, the coastal creeks help to extend the natural habitat from the ridges to the coast. An area almost entirely of dry sclerophyll forest exists to the south of Pottsville.

To the north, koala habitat is found at Chinderah, Ulkerabagh Nature Reserve and adjoining land. Little sclerophyll forest remains in Tweed Heads South, much of which was removed as the freeway construction by the Road and Transport Authority proceeded in 1990. The perimeters of both the Terranora Broadwater and Cobaki Broadwater are mainly dry sclerophyll forest. Areas around Terranora and Bilambil contain koala habitat mainly along the creeks.

In the west of the shire, large areas have been cleared and suitable vegetation is restricted to the length of the water courses. Many ridgelines and watercourses serve as habitat corridors. Ridges of hardwood radiating out of Nullum State Forest provide a good example. Wet and dry sclerophyll forest exists on the outskirts of Mount Warning National Park. A continuous strip of vegetation extends up from Wollumbin State Forest to Bald Mountain and Upper Crystal Creek. The area between Mount Warning National Park and Mt Nullum has a good cover of potential koala habitat, which continues in smaller strips to Burringbar Range and, from there, to the coast.

through links with Mooball State Forest and the coastal creeks.

Vegetation Communities associated with Koalas in the Tweed Shire (Literature Research)

According to "Tweed Coast Plan — Bio-physical Study" (NSW Plan. and Environ. Comm. 1979b) there are seven distinct vegetation types associated with the open forests of the Tweed Shire in which koalas are found. Three types, the Brush Box *Lophostemon confertus*, Blackbutt and the Grey Gum *E. propinqua* — White Mahogany *E. acmenoides* forests are found in the coastal ranges. Brush Box forests occupy the lower slopes, representing a transition between the eucalypt-dominated upper slopes and rainforest species along the creeks. Blackbutt forests tend to dominate the upper slopes while in the driest and most exposed locations the Grey Gum and White Mahogany forests are found.

In the wet lowland areas four forest types predominate. Swamp Mahogany *E. robusta* forests occur in a narrow band at the base of Round Mountain, occupying a transitional zone from dry to wet soil conditions. Swamp Mahogany is also found along low lying areas associated with the coast, Ukerebagh Nature Reserve, Terranora and Bilambil Heights. Forest Red Gum *E. tereticornis* and Pink Bloodwood *E. intermedia* forest occur in Bilambil Heights, Tweed Heads South, Ukerebagh Nature Reserve and along the coastal zone from Kingscliff to Wooyung.

Extensive Broad-leaved Paperbark *Melaleuca quinquenervia* forests occur throughout the shire on all types of alluvial soils in those areas subjected to high water tables that are regularly flooded by fresh water. As the frequency of inundation and soil salinity increases towards estuarine waterbodies, the Paperbark forests give way to open forests dominated by Swamp Oak *Casuarina glauca*. Both the Paperbark and Swamp Oak forests are an important component of wetland communities.

In general, areas on quartz soils (Mooball and Tyalgum) support Blackbutt forests. Ironbarks *E. paniculata* are restricted to drier ridges and slopes while Flooded Gum is found in wetter gullies and on more fertile soils. Tallowwood *E. microcorys* prefers higher rainfall and better soils and grows at higher altitudes. In swampy areas are the White Mahogany and Swamp Mahogany, and on the poorer sandy soils the Bloodwoods *E. gunnifera* and *E. intermedia* and Scribbly Gum *E. signata* predominate.

A more detailed list of dominant and sub-dominant tree species is given in Table 1 for the major areas occupied by koalas in the shire.

Potential Habitat of Particular Value to the Koala

Outside the national parks, reserves and state forests the habitat suitable for koalas is being constantly fragmented and isolated. For example, Tweed Heads South once contained prime koala habitat, but now the remaining few isolated fragments of secondary vegetation could not ensure the long-term preservation of the koala in this area. This view is consistent with that of Summerville (1990). The degree of disturbance affects the ability of an area to support koalas in the long term (NSW Plan. and Environ. Comm. 1979a). The natural communities have been highly disturbed over most of the area and this degraded the remaining areas (NSW Plan. and Environ. Comm. 1979a).

The Tweed Shire does not have large areas of potential habitat; therefore it is important to retain a series of smaller, inter-connected patches to allow koalas to disperse. The usefulness of expanding the areas of optimum koala habitat within Tweed Shire with mixed species plantings (i.e., habitat recreation) should be incorporated in future plans. Tree corridors connecting habitat areas may vary in width and tree diversity (Gordon 1988; Pahl et al. 1989). Corridors do not appear to be a limiting factor for koala movement, however, because koalas will move through lightly timbered areas (Faulks 1990; Moon 1990). Thus corridors may consist of scattered trees in rural areas for example, along ridgelines and verges of creeks and also as incorporated into farm design. Gordon (1988) suggests a maximum tree spacing of 20 metres as being adequate, although ideally it is best to conserve as much timbered area as possible.

Research, in the form of koala movement studies utilizing radiotelemetry equipment, is required in order to understand how koalas use the space and resources available to them. Such studies have important implications with regard to population and habitat management; the development of planning strategies that incorporate suitable range areas for koala populations; the identification of key sites for conservation; the formulation of tree planting schemes including the design of corridors or greenbelts; clearing practices; and an increased understanding of the population structure of koalas, tree usage patterns and preferred structure of habitat. One such study by Faulks (1990) found that koalas showed a high fidelity for a home region where they were selecting for a particular tree species (which varied between individuals), and were not moving randomly. In this study the koala's average home range size was two hectares, although this was largely dependent on its age, sex, the density of eucalypts (i.e., habitat differences), and social factors that affect the dispersion of males, as well as the method used to determine home range. On average,

Table 1. Vegetation communities associated with major areas occupied by koalas in the Tweed Shire (based on a literature review).

Site	Vegetation Unit	Dominant Plant or Forest Type	Sub-Dominant Vegetation
1. Bilambil Heights (TSC 1989; Mundy, pers. comm. 1989)	Mixed Eucalypt (Tall Open Forest)	Brushbox Forest (<i>Lophostemon confertus</i>)	Turpentine (<i>Syncarpia glomulifera</i>) Flooded Gum (<i>Eucalyptus grandis</i>) Exotic plant species — Camphor laurel (<i>Cinnamomum camphora</i>)
		Blackbutt Forest (<i>E. pilularis</i>)	Forest Red Gum (<i>E. tereticornis</i>) Grey Gum (<i>E. propinqua</i>) Brushbox (<i>L. confertus</i>) Small-leaved Peppermint (<i>E. nicholii</i>)
		Swamp Mahogany Forest (<i>E. robusta</i>)	*
	Open Forest	Broad-leaved Paperbark Forest (<i>Melaleuca quinquenervia</i>)	*
2. Tweed Heads South (TSC 1988; Reid, pers. comm. 1989)	Broad-leaved Paperbark (Open Forest)	Broad-leaved Paperbark (<i>M. quinquenervia</i>)	Red Bloodwood (<i>E. gummifera</i>) Swamp Mahogany (<i>E. robusta</i>) Forest Red Gum (<i>E. tereticornis</i>) Swamp She-Oak (<i>Casuarina glauca</i>)
	Mixed Eucalypt (Tall Open) Forest	Forest Red Gum (<i>E. tereticornis</i>) Pink Bloodwood (<i>E. intermedia</i>) Red Mahogany (<i>E. resinifera</i>) Spotted White Gum (<i>E. maculata</i>) Grey Box (<i>E. moluccana</i>)	Blackbutt (<i>E. pilularis</i>)
3. Ukerabagh Nature Reserve (NSW Plan. and Environ. Comm. 1979b).	Mixed Eucalypt (Tall Open) Forest	Forest Red Gum (<i>E. tereticornis</i>)	Swamp Mahogany (<i>E. robusta</i>) Tallowood (<i>E. microcorys</i>)
4. Chinderah (Reid, pers. comm. 1989)	Tall Open Forest	Grey Gum (<i>E. propinqua</i>) Forest Red Gum (<i>E. tereticornis</i>)	Broad-leaved Paperbark (<i>M. quinquenervia</i>)
5. Kingscliff South (TSC 1987b)	Open Forest, canopy height 10–30 m, mid-dense foliage coverage in canopy	Blackbutt Forest (<i>E. pilularis</i>), <i>acmenoides</i>	White Mahogany (<i>E. acmenoides</i>) Red Mahogany (<i>E. resinifera</i>) Grey Gum (<i>E. propinqua</i>) Forest Oak (<i>C. torulosa</i>) Brushbox (<i>L. confertus</i>) Red Ash (<i>Alphitonia excelsa</i>)
		Grey Gum (<i>E. propinqua</i>) White Mahogany Forest (<i>E. acmenoides</i>)	Red Bloodwood (<i>E. gummifera</i>) Blackbutt (<i>E. pilularis</i>) Sydney Blue Gum (<i>E. saligna</i>) Tallowood (<i>E. microcorys</i>) Red Mahogany (<i>E. resinifera</i>) Forest Oak (<i>C. torulosa</i>)
		Swamp Mahogany Forest (<i>E. robusta</i>)	Pink Bloodwood (<i>E. intermedia</i>) Red Mahogany (<i>E. resinifera</i>) Grey Gum (<i>E. propinqua</i>) White Mahogany (<i>E. acmenoides</i>)
		Broad-leaved Paperbark Forest (<i>M. quinquenervia</i>)	Principally mono-specific shrubs and ground cover.
		Swamp She-Oak (<i>C. glauca</i>)	Principally mono-specific shrubs and ground cover.

Table 1 — *continued*

Site	Vegetation Unit	Dominant Plant or Forest Type	Sub-Dominant Vegetation	
6. Cudgen Lake-Round Mountain (NPWS 1989) (Milledge 1988)	Eucalypt and Swamp Open Forest	Broad-leaved Paperbark (<i>M. quinquenervia</i>) Swamp Forest Swamp Mahogany (<i>E. robusta</i>) Blackbutt Forest (<i>E. pilularis</i>) Grey Gum (<i>E. propinqua</i>) Blackbutt (<i>E. pilularis</i>) Tall Open Forest Forest Red Gum (<i>E. tereticornis</i>) Pink Bloodwood (<i>E. intermedia</i>) Swamp Turpentine (<i>L. suaveolens</i>) Scribbly Gum (<i>E. signata</i>) Wallum Banksia (<i>Banksia aemula</i>) White Mahogany (<i>E. acmenoides</i>) Pink Bloodwood (<i>E. intermedia</i>) Tallowwood (<i>E. microcorys</i>) Blackbutt (<i>E. pilularis</i>) Grey Gum (<i>E. propinqua</i>) Grey Ironbark (<i>E. siderophloia</i>) Scribbly Gum (<i>E. signata</i>) Red Mahogany (<i>E. resinifera</i>) Pink Bloodwood (<i>E. intermedia</i>) Tallowwood (<i>E. microcorys</i>) Blackbutt (<i>E. pilularis</i>) Scribbly Gum (<i>E. signata</i>) Pink Bloodwood (<i>E. intermedia</i>) Swamp Mahogany (<i>E. robusta</i>) Broad-leaved Paperbark (<i>M. quinquenervia</i>)	*	
7. Pottsville (TSC 1987a)	Open Forest/ Woodland	Brushbox (<i>L. confertus</i>) Forest Red Gum (<i>E. tereticornis</i>) Swamp Turpentine (<i>L. suaveolens</i>) Broad-leaved paperbark (<i>M. quinquenervia</i>) Bloodwood (<i>E. intermedia</i> , <i>E. gummifera</i>) Swamp She-Oak (<i>C. glauca</i>) Swamp Mahogany (<i>E. robusta</i>)	*	
8. Mt Nullum (Kooyman pers. comm. 1989)	Open Forest (Wet and Dry Sclerophyll)	Flooded Gum (<i>E. grandis</i>) Grey Gum (<i>E. propinqua</i>)	Blackbutt (<i>E. pilularis</i>) Pink Bloodwood (<i>E. intermedia</i>) Red Mahogany (<i>E. resinifera</i>) Tallowwood (<i>E. microcorys</i>)	
9. State Forests (Kooyman, pers. comm. 1989)	Open Forest	Tallowwood (<i>E. microcorys</i>) Flooded Gum (<i>E. grandis</i>) Blackbutt (<i>E. pilularis</i>)	Sydney Blue Gum (<i>E. saligna</i>)	

Table 1 — continued

Site	Vegetation Unit	Dominant Plant or Forest Type	Sub-Dominant Vegetation
10. Mebbin Springs (Gilmore and Milledge 1984)	Open Forest	Tallowwood (<i>E. microcorys</i>) Pink Bloodwood (<i>E. intermedia</i>) White Mahogany (<i>E. acmenoides</i>) Turpentine (<i>S. glomulifera</i>) Sydney Blue Gum (<i>E. saligna</i>) Flooded Gum (<i>E. grandis</i>)	Grey Gum (<i>E. propinqua</i>) Grey Ironbark (<i>E. siderophloia</i>) Brushbox (<i>L. confertus</i>) Grey Ironbark (<i>E. siderophloia</i>)

*No data available

koalas were shown to move 65 m a day, and to use three trees during this period. The population structure of the koalas studied appeared to be maintained by the presence of long-term residents, as well as the arrivals and departures of non-residents. Faulks' (1990) study showed that koalas were co-existing with grazing as a major land use, although to successfully maintain koalas in such areas the support of landowners is necessary. The study suggested that plantings can take the form of scattered trees (20 to 30 m apart) since animals will utilize such areas, and that clearing practices should aim to leave studded or scattered trees of preferred food source (ensuring that trees are continuously replaced in time by younger trees).

The potential habitat areas of particular value to the koala in Tweed Shire are listed in order of importance:

1. *Round Mountain–Cudgen Lake*. Although there is evidence of disturbance from fire, logging, sandmining and banana plantations, the area of vegetation extending from Round Mountain–Cudgen Lake to Hastings Point in the south, and along the ridgeline to Stotts Creek, is one of the largest continuous areas of natural vegetation remaining along the coast. When comparing frequency of koala sightings and habitat, this area is of particular importance because it supports the majority of koalas within the shire. The high density of koalas recorded by Milledge (1988) in the proposed Cudgen Nature Reserve area supports this view. The long-term survival of koalas at Round Mountain, Cudgen Lake and surrounds will require the resolution of problems associated with urban development (particularly in South Kingscliff). The preservation of this land as a nature reserve (outlined by NPWS 1989) would greatly enhance the survival of koalas within the shire.

2. *Condong Range*. The areas of open eucalypt forest associated with the Condong Range are of particular importance because they act as a link between the coast and Moaball State Forest, and the vegetation in this area should be protected from tree removal.

3. *Ukerebagh Nature Reserve*. The wetland forests of this reserve and nearby areas support a small number of koalas. This area is considered valuable because it is the last remaining area of Tweed Heads South supporting koalas, due to the extensive surrounding disturbance. Supplementary planting of mixed species (which could be monitored over the long-term) on the Coolangatta-Tweed Heads Golf Course is recommended to increase the area's wildlife habitat value.

4. *Mount Warning–Mt. Nullum–Burringbar Range*. The presence of koalas in these areas and associated habitat makes this an important koala corridor. The fact that the majority of the area is rural land suggests controls be placed on land use by the Local Government. Some of this habitat is presently zoned as "Environmental Protection" 7(d) and 7(l).

5. *Ridges and Creeks*. In the west of the shire potential koala habitat tends to occupy the steeper ridges and creek levees. These are important corridors for koalas between state forests and other significant vegetated areas, and restrictions on further clearing along with tree planting programmes, would not only increase the viability of these areas to serve as wildlife corridors, but would also increase the value of the land to the farmer.

6. *State Forests*. These forests support koalas at low densities but are important because they provide additional dispersal areas, and as links to more significant habitat areas.

PLANNING CONSIDERATIONS AND CONSTRAINTS IN THE TWEED SHIRE

Tweed Local Environment Plan 1987

The aim here is to examine the planning considerations and constraints under the Tweed Local Environment Plan (LEP) 1987. The "Environmental Protection Zones" in the Tweed Shire for 1988 are shown in Figure 2. The Ukerebagh Nature Reserve at Tweed Heads South is zoned 8 (national parks and nature reserves). The LEP

for Kingscliff South (adjoining Cudgen Lake) was amended in 1988 and areas originally zoned 1(d) — Development Investigation have been rezoned to include zones 2(c) — Urban Expansion, 2(e) — Residential Tourist, 2(t) — Tourist Area, and 6(c) — Special Purposes (recreation). These new zonings surround an area of Broad-leaved Paperbark and Swamp She-oak Forest to the north of Cudgen Lake. A 7(d) — Environmental Protection (Wetlands) zone is currently in place in this swamp area.

Development proposals for the Kingscliff South area are for low density residential development surrounding an artificial lake, although tourist accommodation is a likely possibility for the coastal strip (Doss, pers. comm., 1989). Development pressure along the coast is intense, with several residential and tourist developments being planned or considered for other areas, including Wooyung, Black Rocks, Pottsville, Hastings Point and

Bogangar (including freehold land zoned "Environmental Protection" in the vicinity of Cudgen Lake and Round Mountain). To ensure that development does not conflict with koala preservation in such an important habitat as Cudgen Lake and Round Mountain, the inclusion of the proposed Cudgen Nature Reserve in the LEP is recommended.

The "Environmental Protection" zones within the shire mostly coincide with areas identified as being of high value to koalas. They tend to link up inland state forests, national parks and nature reserves to coastal areas through rural lands. There were several areas with koala sightings not included in the "Environmental Protection" zone. These are:

- The ridgeline associated with Condong Range, north of Round Mountain to Stotts Creek which contains a high frequency of koala sightings, is zoned Rural

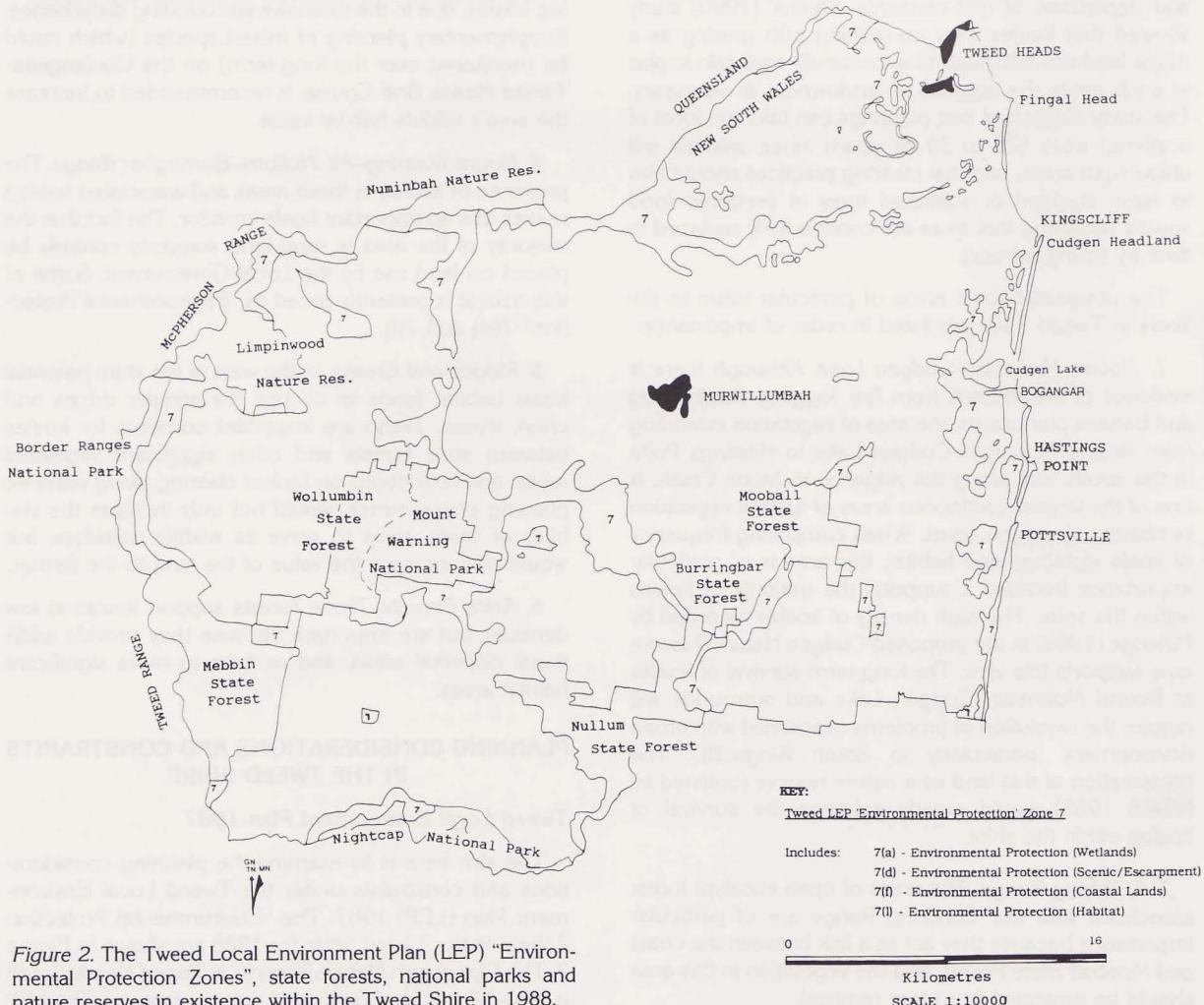


Figure 2. The Tweed Local Environment Plan (LEP) "Environmental Protection Zones", state forests, national parks and nature reserves in existence within the Tweed Shire in 1988.

1(1b) — Agricultural Protection — along most of its length, and warrants investigation for a Tree Preservation Order on important habitat areas along the ridgeline and not just for individual tree species.

- The open eucalypt forest of the Condong Range is an important corridor for the movement of koalas because of its link with Mooball State Forest and its inclusion as Zone 7(l) in the LEP warrants investigation.
- An area of scattered timber to the north of Round Mountain Village (including Portion 87 — Cudgen Parish) was identified as an important area for koalas and its inclusion as 7(l) in the LEP warrants consideration.
- In order to join "Environmental Protection" zones at Round Mountain—Cudgen Lake area and the strip above Mooball State Forest, habitat retention or plantings of preferred koala food trees along the coastal creeks should be encouraged. This is particularly the case for Reserve and Christies Creeks.
- The koala sightings near Sleepy Hollow (on private landholdings) are not covered under Zone 7(l) but the potential koala habitat found along the lengths of the water courses may serve as a corridor for koala movement.
- Regular sightings of koalas were recorded along the length of Cudgera Road. The area consists of scattered eucalypt-dominated forest on freehold land which may be, in its present landuse, adequate for koalas.

The Security of Koalas at Key Conservation Sites

The security of the areas identified as being valuable koala habitat are as follows:

1. *Round Mountain—Cudgen Lake.* The security of koalas here will require resolution of matters relating to development of freehold land in the vicinity of Cudgen Lake and Round Mountain, as well as areas identified for urban development in South Kingscliff. The preservation of land under the proposed nature reserve status would greatly enhance the survival and long-term viability of the koala within this area. The ridge extending to Stotts Creek in the north of Round Mountain is currently zoned "Rural" and security of koala populations in this area is dependent upon the farming practices used in the future. Enforcing regulations relating to land clearing on steep slopes is recommended.

2. *Condong Range.* The Range consists of rural landholdings on steep terrain. The security of koalas in the areas of open eucalypt forest is dependent upon farming practices and regulations relating to the clearing of land

on steep slopes. Inclusion of this corridor as "Environmental Protection" would improve security for koalas.

3. *Ukerebagh Nature Reserve.* The koalas and associated vegetation are secure although planting of preferred food trees in the adjoining Tweed Heads—Coolangatta Golf Course would enhance their probability of long-term survival in this region. The nearby urban areas and associated major roads will be a problem for transitory koalas.

4. *Mount Warning—Mt Nullum—Burringbar Range.* This area, which acts as a wildlife corridor, is protected under "Environmental Protection" zonings. Since most of the area is on rural lands, it enables controls to be placed on land use by local government. The use of a Tree Preservation Order within the shire is used to control the loss of important tree species, but it would better serve its purpose if it related to areas of important habitat. Security of koalas within this area is currently dependent upon the co-operation of rural landholders. Since completion of the study in 1989, a Commission of Enquiry has recommended that re-zoning of land at Mt Nullum (to accommodate a development proposal) not proceed.

5. *Ridges and Creeks.* The security of koalas on steep ridges and along creeks depends upon regulations preventing clearing. Reafforestation of ridges and creeks would be an advantage to koalas, but this would depend upon the co-operation of rural landholders, the involvement of government organizations and interested members of the public.

6. *State Forests.* The security in these areas depends upon the plans of the Forestry Commission, particularly logging and an altered fire regime. Studies on the effects of these activities on koalas warrant investigation.

RECOMMENDATIONS AND CONCLUSIONS

Local government can play a substantial role in the conservation of the koala in the Tweed Shire. Areas identified as being of particular value to the koala should be taken into consideration in any future planning. Many koalas sighted in this study were on private and leasehold lands. Conservation of these koala populations, even though they may be distributed patchily in some cases, can be assisted by means of simple controls, such as Tree Preservation Orders, to restrict clearing of timber on sites important for koalas. These controls are generally the province of local government.

"Environmental Protection" zones and Tree Preservation Orders have been used by the Tweed Shire Council. The difficulty in enforcing restrictive controls on private land could reduce their effectiveness over land use in real terms, and Tree Wardens may need to be used more

extensively to uphold Tree Preservation Orders. The acquisition of wildlife habitat is another option available to governments. Outside the system of national parks, nature reserves and state forests, there are currently no reserves that have koala conservation as one of their management objectives. Education of land owners on the need for habitat preservation and the methods of achieving it has a more positive and potentially successful role than further restrictive legislation.

The key to managing the koala will be to conserve it within its preferred locations, particularly the Round Mountain and Cudgen Lake area. Council should amend its LEP to support National Parks and Wildlife Service's acquisition of the proposed Cudgen Nature Reserve, and to protect the ridgelines associated with Condong Range and the coastal creeks as wildlife corridors which link up with inland areas. Existing corridors along ridgelines and verges of creeks should be retained, and reafforestation programmes could form a basis for future work involving landowners, government departments and public interest groups. In the west of the shire, the habitat requiring most protection links the state forests between Mount Warning, Mt Nullum and Burringbar Ranges.

Once areas of high conservation value for koalas have been identified and secured, further options include: reafforestation programmes; promotion of "Trees on Farms"; education of the community on the importance and benefits of planting patches of mixed local species within or adjacent to core areas utilized by koalas, or in the form of corridors that link habitats; sub-division redesign to reduce impacts on important habitats; review of current planning provisions for the preservation of the koala within the shire to evaluate how supportive they are of sound management; and encouragement of further studies to aid in making sound management decisions. The distribution of koalas warrants further investigation, especially in the west of the shire, since landholders were not systematically approached and as a result there may be other significant koala sites which have not yet been recorded. Koala mortality should be a major focus of further studies, particularly road kills and disease since this survey only dealt with the presence or absence of koalas.

Planting areas of former optimum habitat with mixed species, including preferred food trees, would be justified if habitat requirements of koalas within a region are not being met. This would be particularly important for Round Mountain and Cudgen Lake. Reafforestation programmes and promotion of "Trees on Farms" should aim to restore natural vegetation along the verges of creek, ridge tops and on rural land. These strategies are documented by Butz (1985). It should be stressed that tree planting programmes should use local *Eucalyptus*

seed sources and this would involve local seed collection. Education should emphasize the benefits of incorporating potential wildlife habitats into farm design. Encouraging koalas into urban areas by planting koala food trees should be discouraged near highways. It is recommended that further studies into the planting of koala food trees within urban areas are carried out. Also, studies on habitat utilization are needed as well as a detailed investigation of what constitutes koala habitat within the shire.

Local government also has an important role to play in appropriate housing sub-division design. Areas of open space need to be linked to assist with the free movement of koalas between habitat locations. Council should also investigate present planning provisions (including sub-division design strategies, covenants, fencing and speed limits for vehicles) to ensure that koala preservation is taken into account.

Summary of Recommendations

The following are recommendations (listed in order of priority) that have been brought to light by this study:

1. The preservation of the Round Mountain-Cudgen Lake area as a "Nature Reserve".
2. Protection of Condong Range (to Mooball State Forest) under "Environmental Protection" zoning to preserve its value as a wildlife corridor.
3. Education of the rural community with respect to koala preservation and promotion of "Trees on Farms".
4. Further studies of the composition of koala habitat, and the usefulness of expanding koala habitat with mixed tree plantings ("habitat recreation") using local seed sources, particularly on Coolangatta-Tweed Heads Golf Course adjacent to Ukerebagh Nature Reserve.

The study concluded that Tweed Shire Council has a valuable role in the development of koala management strategies for the shire and the implementation of koala preservation measures in the immediate future. The co-operation of the urban community, rural landowners, Tweed Shire Council, relevant state departments (e.g., Department of Planning and National Parks and Wildlife Service) will be required for a management plan to succeed.

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